# Influence of building typology on Indoor humidity regulation


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This article presents a case study to explain the influence of building typologies in regulating indoor humidity, thereby impacting Indoor Environment Quality. Results from Vernacular (adobe) and conventional (brick/concrete) building typologies in the composite climate zone of India have been presented.

**Keywords:** Indoor Environmental Quality, humidity exposure, comfort, indoor air quality, vernacular building materials, moisture regulation, moisture buffering, hygroscopic materials

## Moisture and Indoor Environment Quality

Indoor environment quality (IEQ) is considered an essential determinant of an individual's health, comfort, and productivity [1]. Comfort parameters can be thermal, visual, acoustic, and hygiene. Health includes the ailments and illnesses that an individual might develop as a result of the IEQ. Moisture in the air is an essential determinant of Indoor air quality and affects thermal, visual, and acoustic comfort parameters.

Building Functional Performance (BFP) constitutes a set of functionalities derived by the occupants from the building, e.g., structural integrity, comfort, illumination, etc. Moisture is often attributed to detrimental effects on BFP. **Figure 1** illustrates the aspects of BFP as impacted by moisture in the air.

## Occupant health

Moisture in the building leading to surface condensation, mold growth, etc., especially in air-conditioned buildings, is often associated with Sick Building Syndrome (SBS). A set of health outcomes like asthma, respiratory infections, cough, wheeze, etc., is observed in occupants of such buildings. Apart from this, increased relative humidity levels in the indoor air are associated with increased heat stress in warmer climates. Moisture in the air impacts respiratory, olfactory, cardiovascular, and tactile response causing infections, itching, and allergies. It can also cause neurotoxic symptoms like headache, nausea, lethargy, dizziness, drowsiness, and mental fatigue.

Water vapor in the air acts as a solvent for chemical compounds and carrier of biological contaminants, as evident in the COVID-19 pandemic. Recommendations by WHO [2] highlight the importance of proper moisture management for ensuring occupant health and productivity from natural ventilation.

Shifts between extreme environmental conditions (heat stress) can affect the blood vessels, impacting cardiovascular functioning. It disturbs the immunological response causing infections, allergies, and respiratory distresses. With sudden changes in heat stress, natural body reflexes get affected, which leads to the hampering of the protective layer of the brain [3].

The vital link between any Building typology and Occupant is **indoor air**. Moisture unifies all parameters of the indoor air, yet strangely remains the least explored. Building typology (materials) regulate indoor air, determining the Indoor Air Quality (IAQ) to which occupants are exposed. IAQ of an indoor space is an essential determinant of occupant comfort, productivity, and health conditions; hence, it must be understood.

## Study Overview

The objectives of the study were as follows:

- To understand moisture variations in naturally ventilated: Conventional (Brick / Concrete) and Vernacular (Adobe) dwellings.
- To understand the perceived discomfort due to moisture in the air.

Results obtained by monitoring temperature and relative humidity in a building cluster (details are shown in **Figure 2**) in India's Jamgoria village situated in composite climate zone for a year are presented.

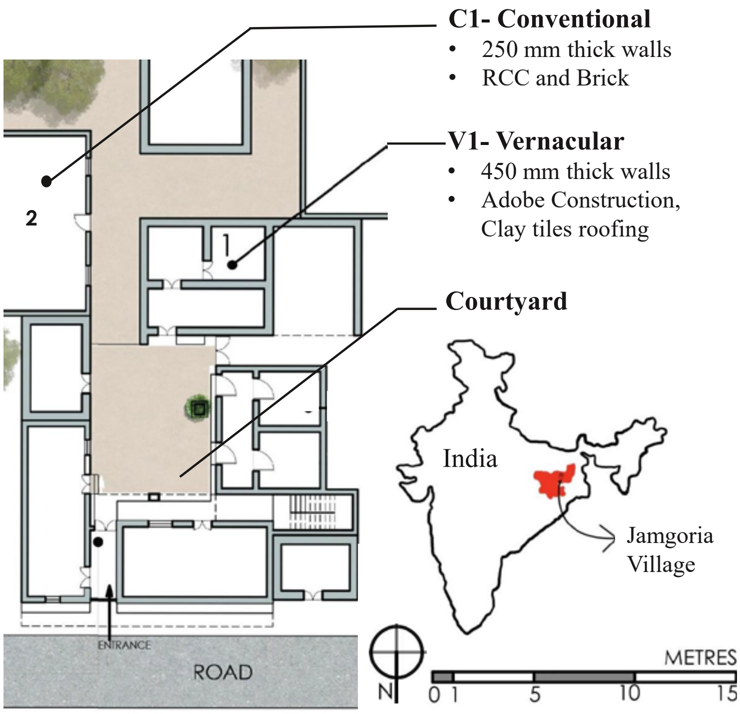


**Figure 2.** Location and details of the Jamgoria Cluster.

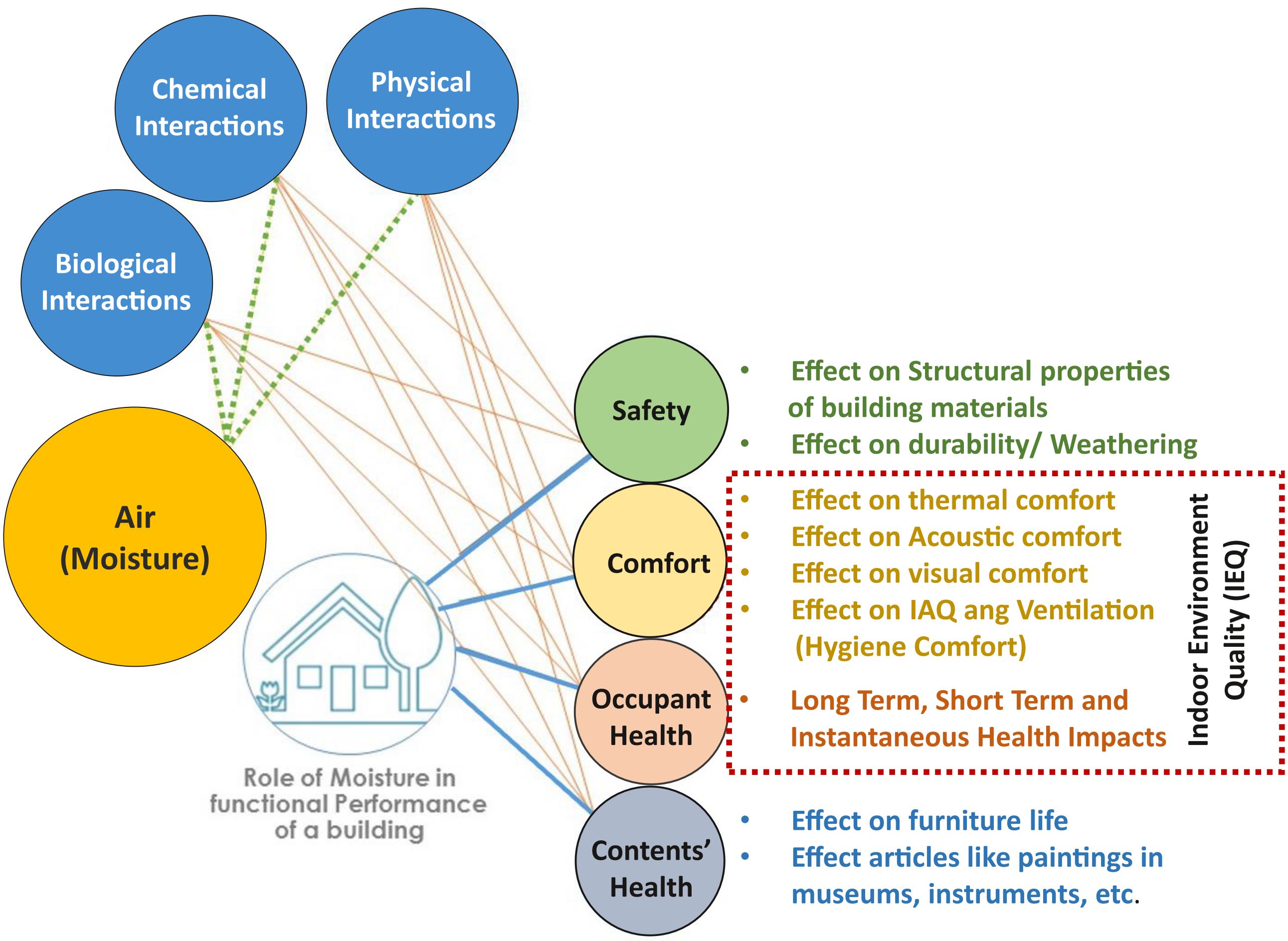


**Figure 1.** Impact of moisture on Indoor Environment Quality.

On-field occupant survey based on an aggregate comfort approach [4] was conducted to understand the perception of thermal, respiratory, and sensory comfort due to air moisture. 50 occupants (33 Males and 17 Females, 13 vernacular and 27 conventional dwelling residents) living in the community were interviewed.

The models [5], [6] are used to calculate discomfort for respiration reported as Warm Respiratory Comfort (WRC) and discomfort for skin contact reported as Indoor Air Quality (IAQ). Survey results were compared to the results obtained from these models to understand their applicability.

## Vernacular vs. Conventional building typology

Humidity ratio in kilograms of water vapor per kilogram of dry air (kg-wv/kg-da) was based on psychrometric computation concurrent with measured temperature and relative humidity in different rooms.

The adobe (vernacular) buildings moderate and dampen the peaks of the diurnal trends of humidity ratio. This effect is seen more in the colder seasons of the year. The dropping of humidity ratio values in conventional buildings even below the outdoors (courtyard) indicates the possibility of interstitial accumulation or condensation. The maximum limits of humidity ratio for occupant comfort are 0.012 kg-wv/kg-da suggested by ASHRAE [7]. In a study from China, revised value [8] 0.0188 kg-wv/kg-da, was proposed, and was further revised [9] to 0.017 kg-wv/kg-da.

As shown in **Figure 3**, during the summer and monsoon months, the average humidity ratio remains much above the recommended values and lowers as the winter approaches. However, the winter month of November remains in close consonance with ASHRAE recommendations. This observation suggests the need to revisit the optimum humidity exposure recommendations in warm and humid climates.

Earth/Adobe is hygroscopic and regulates the indoor environment by moderating the change in conditions indoors. It can moderate exposure variations during the transition from outdoor to indoor environments and diurnal exposure indoors, thereby inhibiting sudden changes in heat stress.

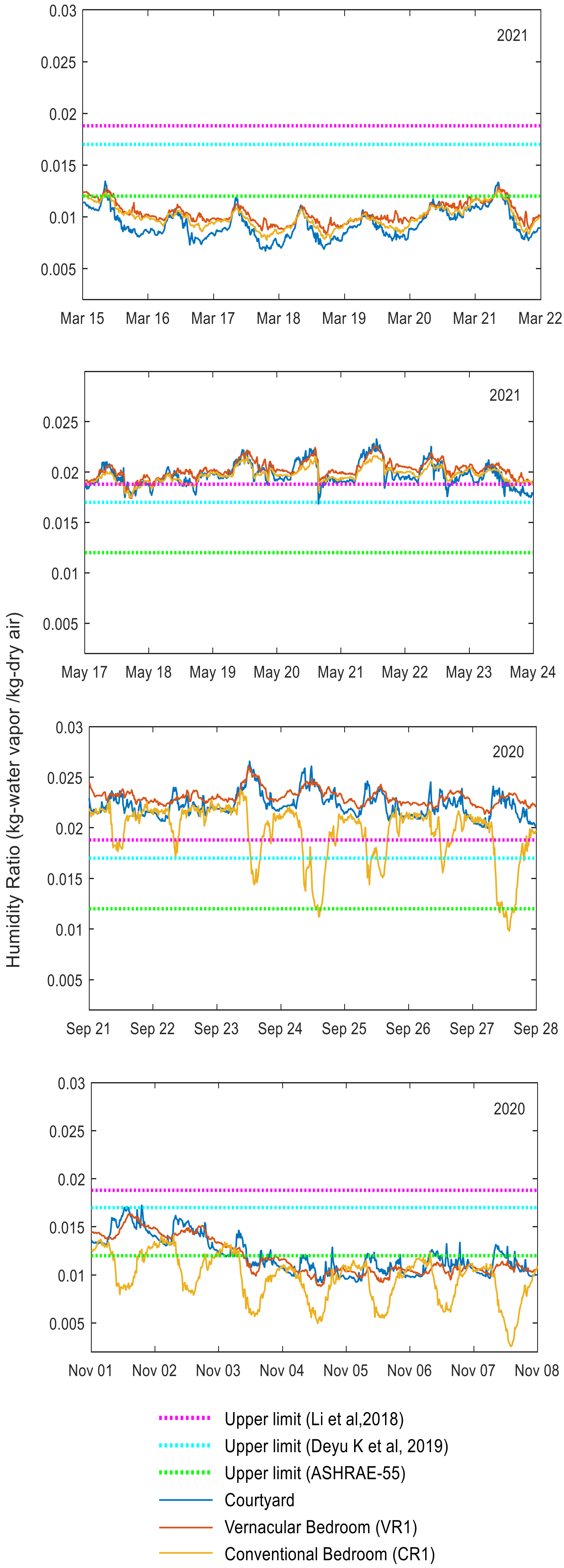


**Figure 3.** Trends of humidity ratio in different months.

## Indoor air quality and respiratory comfort in different moisture exposure conditions

Survey results have been summarized in **Figure 4**, **Figure 5**, show the variation of Thermal Sensation Response, Warm Respiratory Comfort votes. Occupants have reported dry skin and respiratory problems due to dry air in the colder months. Responses indicate perception of humid air for respiration more in the vernacular room compared to conventional room.

Response for IAQ (skin) perception in vernacular show coherence with the change in outdoor humidity conditions unlike in conventional room. Cultural practices of the community reflect adaptation strategies to cope with changing humidity conditions. For example, "oil bath" during Diwali festival in November (low humidity, beginning of winter) for skin hydration, and bath with "ubtan" (Scrub paste made of natural ingredients) to remove excess oil and dirt during Holi festival in March (high humidity, beginning of summer).

Calculations using the models [5], [6] show that humidity parameters in all rooms appear conducive for respiratory comfort (5-10 % dissatisfied) during all seasons. IAQ in all rooms is dissatisfactory (nearly 100% dissatisfied) during the rainy months.

Dissatisfaction for IAQ decreases during the winter months as the outdoors get colder and drier. However, the occupant survey shows disparity with these results. **Figure 6**, and **Figure 7** show the comparison between observed and model-based computed values.

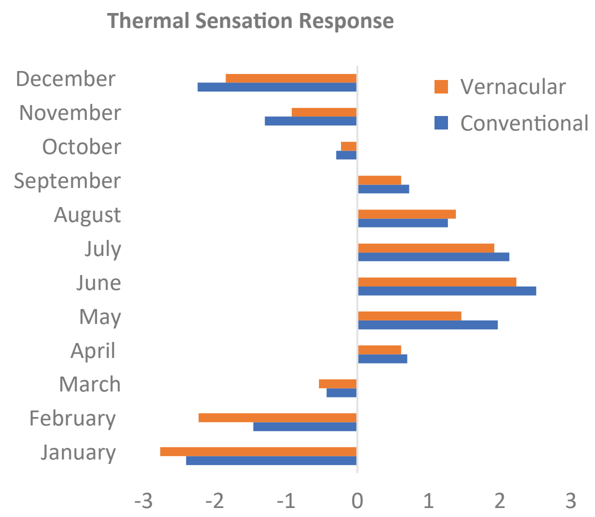


**Figure 4.** Monthly aggregated Thermal Sensation Response (-3 Very Cold to +3 Very hot Scale).

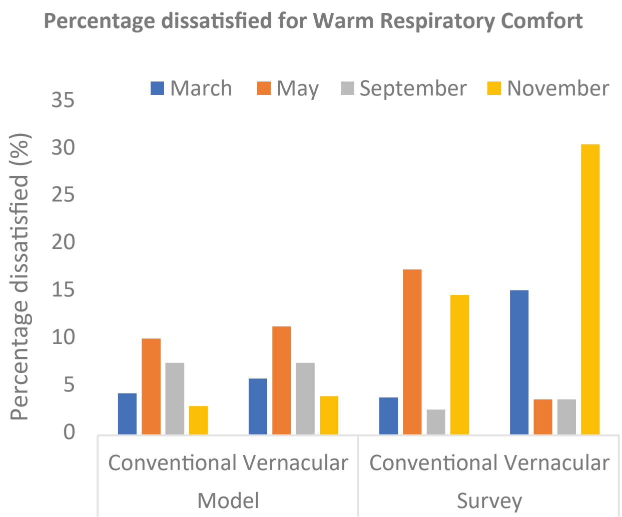


**Figure 6.** Comparison between observed and model-based computed values of percentage dissatisfied for WRC.

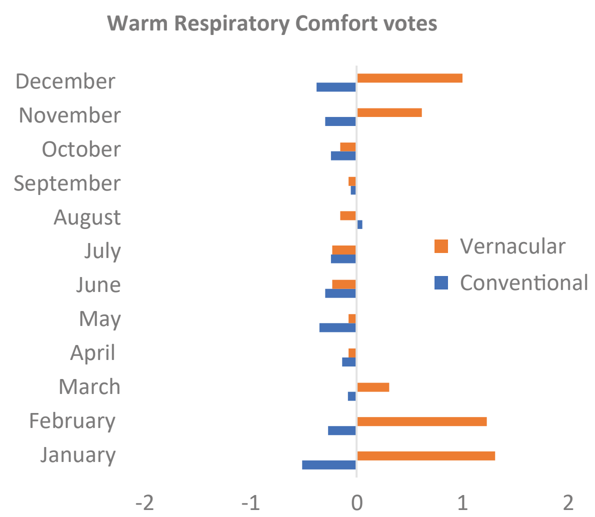


**Figure 5.** Monthly aggregated Warm Respiratory Comfort Votes (-2 Very dry to +2 Very Humid Scale).

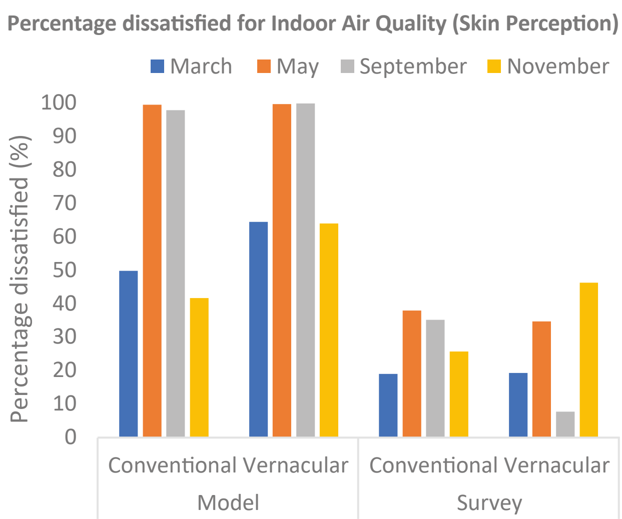


**Figure 7.** Comparison between observed and model-based computed values of percentage dissatisfied for IAQ.

## Major findings

- Vernacular construction, in comparison with conventional construction, maintains indoor conditions close to outdoors and may contribute to improved occupant wellbeing
- The disparity observed between occupant responses received and the computed results advocates examining the applicability of the WRC and IAQ models for different climatic contexts and building typologies.

## Conclusion

Moisture is a vital parameter associated with occupant health. Occupants are subject to sudden variation in moisture exposure in conventional buildings, especially during cold weather conditions. This highlights the need to adopt construction materials that can moderate exposure variations and help maintain a healthy indoor environment. Earth-based materials can be explored for their adoption due to their low cost, durability, lower carbon footprint, and thermal properties. The less understood vernacular building typologies need to be understood well for their benefits towards improved indoor environments. The study results highlight the need for scrutiny of building material based on environmental (climatic zone, microclimate, etc.) and personal factors (acclimatization, age, gender, etc.). ■

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